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CONDITIONAL PRODUCTIVITY CONVERGENCE IN CANADA

by
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ABSTRACT

The purpose of this paper is to investigate the determinants of labour productivity growth at the provincial level in Canada over the 1966-1992 period. The model considers differences in the initial level of labour productivity, human capital characteristics, private and public investments, and industry mix as explanatory variables in determining productivity growth. The main results are the following. The rate of human capital accumulation (its effect becomes more significant once the effects of inter-provincial migration are accounted for) and public investment (excluding government investment on non-residential construction) are positively correlated with productivity growth while the initial level of productivity and government consumption are negatively correlated with productivity growth. On the other hand, private investment is not significantly correlated with provincial productivity growth, reflecting the high degree of private capital mobility between regions in Canada. Relatively slow convergence we observe in Canada appears, in part, to be due to differences in the industry mix across provinces.

RÉSUMÉ

Il s'agit, dans ce document, d'examiner les facteurs qui déterminent la croissance de la productivité du travail, au niveau provincial au Canada, pendant la période allant de 1966 à 1992. Le modèle tient compte des différences en ce qui concerne le niveau initial de la productivité du travail, les caractéristiques du capital humain, les investissements des secteurs public et privé et la composition industrielle comme variables explicatives pour déterminer la croissance de la productivité. Les principaux résultats sont les suivants : il existe une corrélation positive entre le taux d'accumulation du capital humain (ses effets sont plus manifestes lorsqu'il est tenu compte des effets de la migration interprovinciale) et l'investissement public (à l'exclusion de l'investissement du gouvernement dans des projets de construction non résidentielle) et la croissance de la productivité, alors que la corrélation est négative entre le niveau initial de la productivité et les achats de biens et services du gouvernement, et la croissance de la productivité. Par ailleurs, l'investissement privé n'est pas lié de façon importante à la croissance de la productivité, d'où le degré élevé de mobilité du capital privé entre les régions canadiennes. La convergence relativement faible observée au Canada semble tenir partiellement aux différences dans la composition industrielle entre les provinces.

1. Introduction

A number of empirical research papers provide an understanding of the growth process. Most of these papers rely on cross-country data to test convergence within the framework of Solow's neoclassical growth model. Mankiw, Romer and Weil (1992) and Knight, Loayza and Villanueva (1993), extending a simple neoclassical growth model to include a proxy for human capital, suggest that human capital is significant in explaining cross-country variations in growth. Even within a large sample of countries, different countries tend to converge to the same level of productivity once differences in human capital are controlled for, thereby suggesting that poor countries need to develop their human capital before they have any chance of catching-up to the productivity levels of rich countries.

There also have been some empirical studies focusing on regional convergence. These are becoming increasingly important since many industrialized countries face difficulty financing regional distribution and stabilization programs. Barro and Sala-i-Martin (1992a, c) analyze unconditional convergence for the United States. Holtz-Eakin (1993b) extends their analysis to test conditional convergence. He finds that, in addition to the initial level of output per worker, both physical and human capital accumulation, the rates of labour force growth, technological progress, and depreciation are significantly correlated with growth in output per worker.[1]

In addition, there have been a number of recent studies focused on regional growth in Canada. Coulombe and Lee (1994) focus on regional disparities in Canada over the 1961-1991 period, and conclude that there is evidence of convergence in Canada for different measures of per capita income and output. Lee and Coulombe (1994) extend this analysis and suggest that labour productivities converge faster than per capita incomes in Canada.

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[1] There are other regional studies focusing on the U.S. states. Carlino and Voith (1992) use a labour demand equation to analyze the determinants of aggregate productivity for U.S. states. They find that differences in aggregate state productivity can be attributed to human capital characteristics, investment in infrastructure, metropolitan structure, a state's industrial structure and other state-specific effects. Helms' (1985) study suggests that increases in state and local taxes significantly retard economic growth when the revenue is used to fund transfer payments. However, when the revenue is used instead to finance public services (such as education, highways, and public health and safety), the negative influence of tax may be outweighed by the value of services. Moreover, Mofidi and Stone (1990) report similar findings. On the other hand, Holtz-Eakin (1993a) does not find additional benefits to private output stemming from investing in state and local government capital. Canto and Webb (1983) use a neoclassical model with mobile and immobile factors to highlight the importance of both state and federal fiscal policies in determining the overall economic performance of a region.

Helliwell (1994) discusses the role of migration on convergence. He finds that both inter-provincial and international migration have been directed toward the richer provinces. Surprisingly, there has been no empirical analysis that considers the effects of human capital, private and public investment, migration and industrial structure on productivity growth and convergence in Canada. Determining the factors that are pertinent to regional productivity growth and convergence are particularly important for policymakers, since these factors can guide them to allocate scarce resources more effectively. The purpose of this paper is to determine these factors and arrive at some policy implications.

The paper finds that there is a significant negative relationship between the initial level of productivity and productivity growth suggesting that there is a tendency for convergence in Canada. This convergence process becomes faster once the determinants of steady state output across provinces are controlled for. Private investment is not significantly correlated with productivity growth, indicating a high degree of capital mobility causing the rate of return on private capital to be equalized across provinces. On the other hand, public investment excluding government investment in non-residential construction is positively correlated with productivity growth. A proxy for human capital becomes more significant once the inter-provincial migration factor is added as an extra explanatory variable, suggesting that migrants tend to carry some human capital with them. The ratio of government consumption to output is negatively correlated with productivity growth.

The rest of the paper is organized as follows. The following section sets up the model. Section 3 discusses the data and empirical results. The last section draws conclusions.

2. The Model

A simple neoclassical model only considers two inputs, namely capital and labour in the production function. However, recent empirical studies (e.g. Carlino and Voith, 1992, Holtz-Eakin, 1992a) suggest that we need to consider other factors such as human capital and different industrial structures in understanding the growth process. Therefore, we use an extended version of the neoclassical model to account for differences in various types of investment and industrial structures. We first introduce an extended neoclassical model and then describe its steady state. The dynamics outside the steady state are described last.

2.1 Augmented Neoclassical Model

The behaviour of public sector capital can be different from that of private sector capital in the economy.[2] We, therefore, extend the Mankiw, Romer, and Weil model (1992) to include public sector capital by assuming the following Cobb-Douglas production function at time t:

$$Y_t = H_t^{\gamma} K_t^{\alpha} G_t^{\beta} (A_t L_t)^{1-\gamma-\alpha-\beta} \tag{1}$$

where Y_t is real output, H_t is the stock of human capital, K_t is the private stock of physical capital, G_t is the public stock of physical capital, L_t is raw labour, and A_t is labour-augmenting technology. The production function implicitly assumes decreasing returns to private inputs unless public capital expands at the same rate.

A_t and L_t are assumed to grow at constant rates, g and n, respectively:

$$A_t = A_0 e^{gt} \tag{2}$$

$$L_t = L_0 e^{nt} \tag{3}$$

A_tL_t denotes the effective labour force which grows at a rate g + n. Each variable is divided by effective labour in order to facilitate our analysis. Let lower case letters with a hat represent quantities per effective unit of labour. Then rewriting production function (1) in terms of the effective labour force yields the following:

$$\hat{y}_t = \hat{h}_t^{\gamma} \hat{k}_t^{\alpha} \hat{g}_t^{\beta} \tag{4}$$

We assume that the savings ratios are exogenously determined either by savers' preferences or by government policy. Therefore, human, private and public capital per effective unit of labour are accumulated according to the following expressions:

$$\dot{\hat{h}}_t = s_h \hat{y}_t - (g + n + \delta)\hat{h}_t \tag{5}$$

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[2] See Aschauer (1989) and Barro and Sala-i-Martin (1990).

$$\dot{\hat{k}}_t = s_k \hat{y}_t - (g + n + \delta)\hat{k}_t \tag{6}$$

$$\dot{\hat{g}}_t^* = s_g \hat{y}_t - (g + n + \delta)\hat{g}_t \tag{7}$$

where s_h, s_k and s_g are the fractions of income invested in human, private and public capital respectively. All three types of capital are assumed to depreciate at the same rate, δ. The term $(g + n + \delta)$ reflects capital requirement necessary to equip effective labour force growth.

2.2 The Steady State

Equations (5), (6) and (7) imply that the levels of human, private and public capital per effective unit of labour are constant in the steady state as shown by the following expressions:

$$\hat{h}^* = \left[\frac{s_k^{\alpha} s_g^{\beta} s_h^{1-\alpha-\beta}}{g + n + \delta} \right]^{1/(1-\gamma-\alpha-\beta)} \tag{8}$$

$$\hat{k}^* = \left[\frac{s_k^{1-\beta-\gamma} s_g^{\beta} s_h^{\gamma}}{g + n + \delta} \right]^{1/(1-\gamma-\alpha-\beta)} \tag{9}$$

$$\hat{g}^* = \left[\frac{s_k^{\alpha} s_g^{1-\alpha-\gamma} s_h^{\gamma}}{g + n + \delta} \right]^{1/(1-\gamma-\alpha-\beta)} \tag{10}$$

Substituting equations (8), (9) and (10) into the production function (4) yields the steady state value of effective-labour productivity:

$$\hat{y}^* = \left[\frac{1}{g + n + \delta} \right]^{\frac{(\gamma+\alpha+\beta)}{(1-\gamma-\alpha-\beta)}} s_h^{\frac{\gamma}{(1-\gamma-\alpha-\beta)}} s_k^{\frac{\alpha}{(1-\gamma-\alpha-\beta)}} s_g^{\frac{\beta}{(1-\gamma-\alpha-\beta)}} \tag{11}$$

In reality, we do not observe output per effective unit of labour. The model, however, can be expressed in terms of output per worker to predict the steady state level of output. Let y denote output per worker, then combining equations (2) and (11) yields:

$$\ln y_t = -\left[\frac{\gamma+\alpha+\beta}{1-\gamma-\alpha-\beta}\right]\ln(g+n+\delta)+\left[\frac{\gamma}{1-\gamma-\alpha-\beta}\right]\ln s_h$$

$$+\left[\frac{\alpha}{1-\gamma-\alpha-\beta}\right]\ln s_k+\left[\frac{\beta}{1-\gamma-\alpha-\beta}\right]\ln s_g+\ln A_0+gt \qquad (12)$$

2.3 Transitions to the Steady State

Expression (12) implicitly assumes that the economy is at steady state. However, in the presence of random shocks and various government policies, it is more likely the economy would be out of steady state. Therefore, in order to describe dynamics outside steady state, we need to assume that the economy is sufficiently close to but not at steady state. We can then approximate transitional dynamics around the steady state by log-linearizing output around it, yielding the following result:[3]

$$\frac{d\ln\hat{y}_t}{dt}=\lambda(\ln\hat{y}^*-\ln\hat{y}_t) \qquad (13)$$

where $\lambda = (1 - \gamma - \alpha - \beta)(g + n + \delta)$. The parameter λ indicates the speed of convergence: how fast output per effective labour is approaching its steady state.

In order to estimate expression (13), we integrate equation (13) from t_0 to t_0+T:

$$\ln\hat{y}_{t_0+T}=(1-e^{-\lambda T})\ln\hat{y}^*+e^{-\lambda T}\ln\hat{y}_{t_0} \qquad (14)$$

Transforming equation (14) into observable output per worker and substituting equation (12) into the resulting expression produces the following:

$$\frac{1}{T}\ln\left[\frac{y_{t_0+T}}{y_{t_0}}\right]=-\left[\frac{1-e^{-\lambda T}}{T}\right]\ln y_{t_0}-\left[\frac{1-e^{-\lambda T}}{T}\right]\left[\frac{\gamma+\alpha+\beta}{1-\gamma-\alpha-\beta}\right]\ln(g+n+\delta)$$

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[3] Derivation is shown in Appendix A.

$$+\left[\frac{1-e^{-\lambda T}}{T}\right]\left[\frac{\gamma}{1-\gamma-\alpha-\beta}\right]\ln s_h+\left[\frac{1-e^{-\lambda T}}{T}\right]\left[\frac{\alpha}{1-\gamma-\alpha-\beta}\right]\ln s_k$$

$$+\left[\frac{1-e^{-\lambda T}}{T}\right]\left[\frac{\beta}{1-\gamma-\alpha-\beta}\right]\ln s_g+\left[\frac{1-e^{-\lambda T}}{T}\right]\ln A_{t_0}+g \qquad (15)$$

In order to analyze the impact of changing the savings rates on growth, equation (15) is differentiated with respect to the savings rate, yielding:

$$\frac{1}{T}\frac{\partial \ln(y_{t_0+T}-y_{t_0})}{\partial s_i}=\left[\frac{1-e^{-\lambda T}}{T}\right]\frac{j}{(1-\gamma-\alpha-\beta)}, \text{ where i = h, k, g, and j = } \gamma, \alpha, \beta. \qquad (16)$$

Thus, the impact of increasing the savings rate at $T=t_0$ on growth declines as T rises.

3. Empirical Analysis

This section presents the estimated models and describes the data. Following the description of the data, empirical results are discussed.

3.1 Econometric Specification

Since Canada is composed of ten provinces, an analysis using cross-sectional data will result in a severe degrees of freedom problem. In order to eliminate this problem, we create a sample of pooled cross-section and time series data by dividing provincial data series from 1968 to 1992 into three sub-periods: 1968-1976, 1976-1984, 1984-1992. Therefore, equation (15) is re-expressed as the following with the addition of an error term, $\varepsilon_{i,t}$:

$$(1/T)\ln(y_{i,t_0+T}/y_{i,t_0})=\theta_0+\theta_1\ln y_{i,t_0}+\theta_2\ln(g+n_{i,t}+\delta_{i,t})+\theta_3\ln s_{h,i,t}$$

$$+\theta_4\ln s_{k,i,t}+\theta_5\ln s_{g,i,t}+\theta_6\ln A_{i,t_0}+\varepsilon_{i,t} \qquad (17)$$

where, i = 1,...,10; t = 1, 2, 3 and T=8. Therefore, t here refers to each sub-period.

Mobility of factors across provinces is crucial for understanding the dynamics of regional growth in Canada. Therefore, equation (17) is modified to consider the open

economy aspects by replacing savings rates s_h, s_k and s_g with investment rates Φ^h, Φ^k and Φ^g. At the same time, we allow regional differences in industrial structure as in Barro and Sala-i-Martin (1992a, c) and Carlino and Voith (1992).[4] Thus, equation (17) is modified as:

$$(1/T)\ln(y_{i,t_0+T}/y_{i,t_0}) = \theta_0 + \theta_1 \ln y_{i,t_0} + \theta_2 \ln(g + n_{i,t} + \delta_{i,t}) + \theta_3 \ln \Phi^h_{i,t}$$

$$+\theta_4 \ln \Phi^k_{i,t} + \theta_5 \ln \Phi^g_{i,t} + \sum_{j=6}^{8} \theta_j \ln x_{i,j,t} + \varepsilon_{i,t} \qquad (18)$$

We can also estimate the parameters of the model based on the steady state productivity level by extending equation (12) to include the same set of right-hand side variables as in equation (18). Thus, the left-hand side variable in this case is the level of real GPP per worker in the last year of each subperiod:

$$\ln(y_{i,T}) = \pi_0 + \pi_1 \ln(g + n_{i,t} + \delta_{i,t}) + \pi_2 \ln \Phi^h_{i,t}$$

$$+\pi_3 \ln \Phi^k_{i,t} + \pi_4 \ln \Phi^g_{i,t} + \sum_{j=5}^{7} \pi_j \ln x_{i,j,t} + \varepsilon_{i,t} \qquad (19)$$

3.2 Data

Equations (18) and (19) are estimated using a sample of ten cross-section and three time series data obtained from dividing annual observations from 1968 to 1992 into three sub-periods. The data for each sub-period are averages of 8 years. The following discussion briefly explains variables used in the paper, and more detailed explanations are given in Appendix A.

The first dependent variable used is the annual average change in productivity (real GPP per worker)[5] over the eight-year subperiod. The second dependent variable considered is the level of real GPP per worker in the last year of each sub-period.

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[4] Mankiw *et al.* (1991) point out the possibility of permanent differences in production functions causing a correlation between different A(0)'s and the initial level of productivity. Allowing regional differences in the industry mix would reduce this possibility.

[5] The Conference Board's estimates of provincial implicit price indices are used to calculate real GPP in order to capture regional differences in output prices.

The initial level of productivity (yi.0) used in estimating equation (18) is the level of real GPP per worker in the first year of each sub-period. The next explanatory variable is the natural logarithm of the sum of labour-augmented technical progress (0.02), the average growth rate of employment and the depreciation rate for the capital stock.[6] Human capital per worker is proxied by the average fraction of workers, aged 15 or older ($\Phi^{h}_{i,t}$), having completed university.[7] The next set of explanatory variables used is the natural logarithm of the average ratios of four different real investments to real GPP: the ratio of private sector investment[8] to GPP ($\Phi^{k}_{i,t}$); the ratio of public sector[9] investment to GPP ($\Phi^{g}_{i,t}$) and further decomposing this ratio into the ratios of public investment excluding government investment in non-residential construction[10] to GPP ($\Phi^{g-if}_{i,t}$) and government investment in non-residential construction to GPP ($\Phi^{if}_{i,t}$). In addition, the natural logarithm of the ratios of real government consumption to real GPP ($gc_{i,t}/y_{i,t}$) and taxes to real GPP ($tax_{i,t}/y_{i,t}$) are also considered.

In order to account for differences in resource endowments and industrial structure, the natural logarithm of the average ratios of three sectors' GPP to real GPP ($x^{j}_{i,t}$) are used: the primary, manufacturing and construction sectors.

Lastly, the net inter-provincial migration rate ($mr_{i,t}$) is used to consider the effects of migration on the convergence process.

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6 The depreciation rate was calculated based on the capital stock excluding residential capital stock since it is not publicly available. This, however, is not likely to change the results significantly.

7 Using the average fraction of workers with high school education does not alter the basic results.

8 Total manufacturing and non-manufacturing industries are defined as the private sector in this paper.

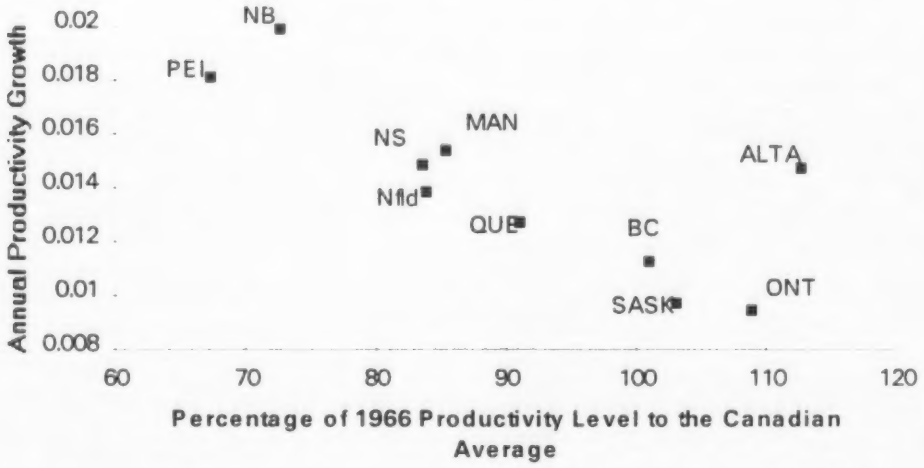
9 Institutions and government departments are defined as the public sector in this paper. Defence-related spending is not included.

10 Government investment in non-residential construction includes spending on highways, bridges and office buildings.

3.3 Empirical Results

Equation (15) predicts that economies that begin with a lower level of productivity will grow faster during their transition path to the steady state. Figure 3.1 confirms this process since the plot of the annual growth rate and the initial level of productivity results in

FIGURE 3.1 Growth Rate versus Initial Level of Productivity



a negative slope. Figure 3.2 provides further evidence of this convergence process where the slope becomes steeper when the annual growth rate is plotted against the terminal level of productivity. But the slope does not become perfectly vertical in Figure 3.2 and there are three possible ways to interpret this. First, the convergence process may not be over, and Canada may be still in the process of moving towards the steady state. Second, it is possible that each province has different steady states, suggesting that all provinces will not reach the same level of productivity in the future. Third, each province's productivity growth is endogenously determined by interactions among different types of capital and government policies. However, this possibility is not pursued any further in this paper since the literature on endogenous growth is still at an infant stage. Interestingly, the dispersion of productivity (measured by the unweighted cross-sectional standard deviation of the logarithm of output

per worker in each year[11]) declined rather steadily over the years as shown in Figure 3.3. This steady decline has reduced productivity gaps among provinces, but productivity did not equalize among provinces by 1992 as shown in Figure 3.4.

FIGURE 3.2 Growth Rate versus Terminal Level of Productivity

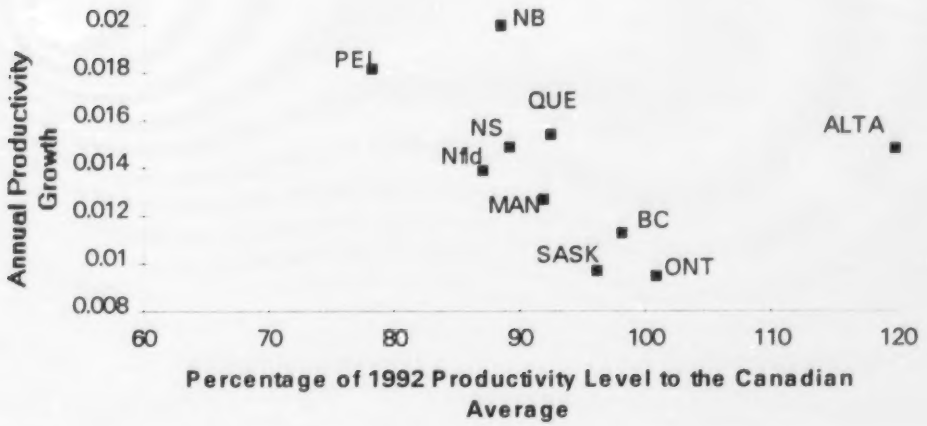
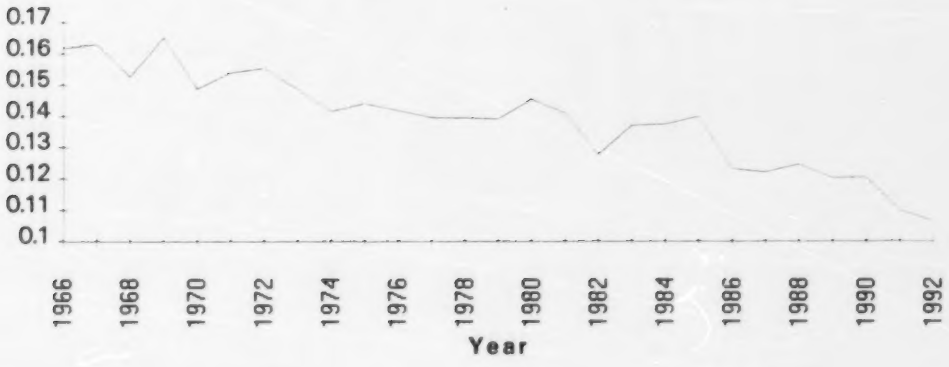
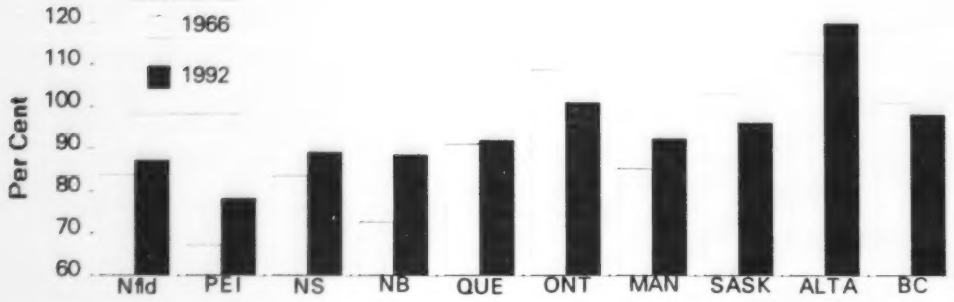


FIGURE 3.3 Dispersion of GPP per worker



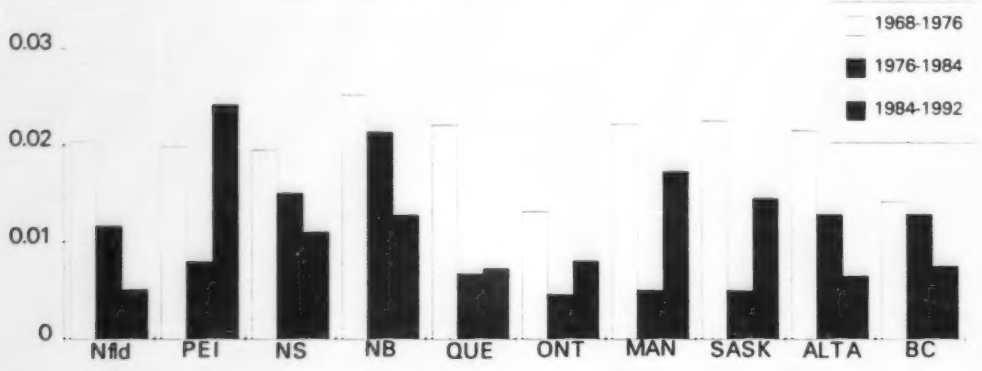
[11] In order to investigate convergence in the growth rates, the dispersion in the natural logarithm of the level of output per worker is examined rather than dispersion in the level. The reason for this is that, if the rate of growth was constant across provinces that start from different levels, the dispersion in the logarithm of the levels will stay constant, but dispersion in the levels will increase.

FIGURE 3.4 GPP per worker as a Percentage of the Canadian Average



The empirical results presented in this paper reflect variations in productivity growth across regions as well as over the three sub-periods, as shown in Figure 3.5, since variables in the analysis are not defined as logarithmic deviations from the Canadian average. It is important to understand the relationship between productivity growth and associated factors across regions as well as over time since each will yield different information that may have different policy implications.

FIGURE 3.5 Annual GPP per worker growth



Before proceeding with the discussion of the empirical results, note that equation (18) describes transitory dynamics, while equation (19) implicitly assumes that provinces are at their steady states. Thus, according to equation (19), adjustments from the initial period to the steady states are completed. But according to the results in Table 3.1, the initial level of productivity is always significant suggesting that there is a partial adjustment towards the steady states. Therefore, our discussion will centre around the estimated results of equation (18) shown in Table 3.1. The estimated results for equation (19) are given in Appendix C.[12]

In regression (1), the initial productivity level appears as the only right-hand-side variable. It is highly significant and explains 40 percent of the variation in productivity growth. According to regression (1), the estimated value for the speed of convergence is 0.0266 per year, implying that the economy moves halfway to the steady state in about 26 years.

Regression (2) includes a proxy for the ratio of human capital investment to GPP, the log of the business and non-business investment shares and different industrial output shares. The human capital measure is positively correlated with productivity growth[13] but other investment shares are not significantly correlated with productivity growth. Primary and manufacturing output shares are also positively correlated with productivity growth. The speed of convergence increases from 0.0266 to 0.0354, once we control for differences in investment shares and industrial structures across provinces. Decomposing the non-business investment share into a non-business investment share excluding government investment in non-residential construction and a government investment share in non-residential construction as shown in regression (3) does not change the basic results other than that the non-business investment share excluding government investment in non-residential construction is significant. Regressions (5) and (6) show that government consumption is negatively correlated with productivity growth. The empirical results pertaining to each variable are discussed in greater detail below.

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[12] The coefficients on $\ln(\Phi_{i,t}^{g-if})$ are significantly different from those reported in Table 3.1 possibly due to the deviations from steady state behaviour.

[13] This proxy becomes much more significant when regressions are performed using data based on deviations from the Canadian average.

Table 3.1 Regressions of Growth on Economic Variablies (1968-1992)

Dependent variable: annual log difference GDP per worker

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.0967**	0.195**	0.193**	0.288**	0.226**	0.296**
	(0.0172)	(0.0583)	(0.0545)	(0.0785)	(0.0594)	(0.0861)
$\ln(y_{i,0})$	-0.0240**	-0.0308**	-0.0321**	-0.0399**	-0.0463**	-0.0510**
	(0.00494)	(0.00812)	(0.00758)	(0.00929)	(0.0117)	(0.0122)
$\ln(0.02+n_{i,t}+\delta_{i,t})$		-0.00253	-0.00490	0.00913	-0.00708	0.00388
		(0.00849)	(0.00867)	(0.0109)	(0.00836)	(0.0122)
$\ln(\Phi^{h}_{i,t})$		0.00810*	0.00395	0.0117*	0.0110*	0.0163**
		(0.00526)	(0.00578)	(0.00681)	(0.00708)	(0.00816)
$\ln(\Phi^{k}_{i,t})$		-0.00609	-0.00724	-0.00416	-0.00769	-0.00528
		(0.00809)	(0.00739)	(0.00840)	(0.00655)	(0.00790)
$\ln(\Phi^{g}_{i,t})$		0.00189				
		(0.00572)				
$\ln(\Phi^{g-if}_{i,t})$			0.00778**	0.00470	0.00575*	0.00358
			(0.00323)	(0.00349)	(0.00328)	(0.00361)
$\ln(\Phi^{if}_{i,t})$			-0.00628**	-0.00320	-0.00302	-0.000960
			(0.00355)	(0.00352)	(0.00382)	(0.00383)
$\ln(gc_{i,t}/y_{i,t})$					-0.0121*	-0.0110*
					(0.00767)	(0.00763)
$\ln(x^{priman}_{i,t})$		0.0121**	0.0148**	0.0144**	0.0115**	0.0115**
		(0.00299)	(0.00254)	(0.00225)	(0.00307)	(0.00290)
$\ln(x^{manu}_{i,t})$		0.0135**	0.0167**	0.0180**	0.0125**	0.0139**
		(0.00361)	(0.00337)	(0.00363)	(0.00408)	(0.00461)
$\ln(x^{const}_{i,t})$		0.00418	0.00160	0.00514	0.00395	0.00646**
		(0.0102)	(0.00940)	(0.00854)	(0.00878)	(0.00825)
$mr_{i,t}$				-0.000391*		-0.000300
				(0.000259)		(0.000279)
Implied λ	0.0266*	0.0354**	0.0371**	0.0481**	0.0578**	0.0655**
	(0.00611)	(0.0108)	(0.0102)	(0.0151)	(0.0185)	(0.0206)
Adj. R^2	0.40	0.47	0.50	0.49	0.51	0.49
$\hat{\sigma}$	0.0051	0.0048	0.0047	0.0048	0.0047	0.0048
Reset (4)	0.753	1.359	0.809	0.652	0.356	0.427

Note: Corrected for heteroskedasticity using White's heteroskedastic-consistent covariance matrix estimation. Numbers in the parentheses indicate standard errors. We reject the null hypothesis of omitted variables according to the Ramsey Specification Test Statistics at the 5 % level of significance. * significant at 10 percent level. ** significant at 5 percent level.

The human capital measure used in all regressions includes the impact of migration across provinces since it is the share of workers with a university degree. Therefore, the speed of convergence in regressions (1), (2), (3) and (5) includes the impact of inter-provincial migration. In order to filter out the effects of this migration, the migration rate is added to regressions (3) and (5). The addition of the migration rate as a regressor causes the coefficient on human capital proxy in regressions (3) and (5) to become much more significant as shown by corresponding t-ratios in regressions (4) and (6).[14] This suggests that the impact of human capital measure on productivity growth is greater once the inter-provincial migration factor is taken into account. The reason is that migrants may have educational characteristics slowing down convergence in contrast to the prediction of a simple neoclassical model (regressions (3) and (5) have lower speeds of convergence compared to those in regressions (4) and (6) suggesting that university-educated workers tend to move from low productivity provinces to high productivity provinces, slowing down the convergence process).[15] This suggests that we need to explore beyond a simple neoclassical model.

There is no significant relationship between the private investment share and productivity growth.[16] This, in turn, suggests that the marginal productivity of physical capital decreases rapidly, probably due to the high degree of private capital mobility in Canada. Thomas (1993) shows that there is no positive relationship between regional personal savings and private investment in Canada.[17] This, in turn, suggests that the flow of private savings from rich to poor regions in Canada dampens the effects of regional disparities caused by regional differences in savings. Furthermore, the relationship may reflect the hypothesis that rich regions generate higher savings but these savings are likely to be redistributed across provinces. Thus, capital inflows from rich to poor regions are partly responsible for the convergence process. In any case, an increase in the saving rate in one

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[14] T-ratios also become significantly higher in regressions based on the deviations from the Canadian average data. However, qualitative results do not change.

[15] This is contrary to a simple neoclassical growth framework which predicts that exogenous in-migration will have a negative effect on growth per worker and that the addition of the migration rate as a regressor will lower the speed of convergence, since workers are motivated to move from low-wage to high-wage area.

[16] Figures showing the ratios of investments and government consumption to GPP are shown in Appendix D.

[17] In contrast to the significant positive relationship in savings and investment across countries.

region does not necessarily translate into a higher investment rate for that region since its effect may spill over to other regions due to the high degree of private capital mobility.

Public investment excluding government investment in non-residential construction is positively correlated with productivity growth in regressions (3) and (5). Since there exist large disparities in government savings, transfers tend to reduce the disparities causing public investment to be more equally distributed than public savings, thereby reducing regional disparities.[18] The effects of capital mobility and transfers tend to dampen regional disparities caused by differences in regional savings. However, private capital flows from rich to poor regions may also have been induced by government policies such as tax concessions and subsidies and therefore do not necessarily reflect an outcome of an efficient economy.[19]

Regression (5) considers the effects of adding the share of government consumption[20] to output. It is negatively correlated with productivity growth. Although not shown here, the share of taxes in output is not significantly correlated with productivity growth. This may be due to the fact that the government budget is not balanced each year and inefficiencies created by government are more accurately depicted by government consumption than by taxes. At the same time, taxes can be used to finance growth-enhancing programs, thereby cancelling distortions created by higher taxes.

In conclusion, the initial level of productivity and primary and manufacturing output shares are significantly correlated with productivity growth. This suggests that there is a tendency for poorer provinces to catch up to richer provinces' productivity levels. This tendency becomes much more pronounced once differences in industrial structure, and human and physical investment are accounted for. There is a significant positive relationship between the human capital measure and productivity growth and this relationship becomes more significant once differences in inter-provincial migration are considered. Thus, inter-provincial migration appears to be selective such that it slows down the convergence process.

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[18] Indeed, Thomas (1993) finds a negative relationship between government savings and investment.

[19] Interesingly, investment is significantly correlated with output per worker in cross-country studies such as in Mankiw, N., D. Romer and D. N. Weil (1992) and Knight, M., N. Loayza and D. Villanueva (1993).

[20] This does not include transfer payments and interest payments on the public debt.

On the other hand, the private investment rate is not significantly correlated with productivity growth. This relationship appears to reflect a high degree of private capital mobility across provinces in Canada. The public investment rate excluding government investment in non-residential construction is positively correlated with productivity growth. In addition, capital mobility and transfers actually appear to have reduced regional disparities created by differences in regional savings.

3.4 Comparisons with other Estimated Results

Table 3.2 presents the estimates of equation (18) with the restriction of constant returns to scale imposed.[21] The restriction is not rejected at the 5 % level of significance for all regressions. This, in turn, suggests that there are constant returns to scale and diminishing returns to each input. Table 3.3 reports the speed of convergence and elasticities of investment implied by the coefficients presented in Table 3.2 in order to compare our results with those obtained from the cross-country and U.S. states studies as shown in Table 3.4. The estimates of γ (0.213, 0.217) from regressions (11) and (12) are fairly close to those for three different samples of countries (0.23) but lower than the estimate for the U.S. states (0.33).

The estimated elasticity of output with respect to capital decreases as the sample becomes similar in terms of preferences, technology and institutions (from 0.48 to 0.29). However for Canada, the estimate of the elasticity of output for private capital is not statistically significant and the estimated elasticity of output for public capital excluding government investment in non-residential construction is between 0.11 and 0.19. This suggests that there is not much variation in private investment across Canadian provinces.

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[21] Table C2 in Appendix C presents the estimates of equation (19) with the restriction imposed. The results are again based on an implicit assumption that the economies are at their steady states. This assumption appears to be responsible for implausible elasticities for public investment. Furthermore, the restriction is not accepted for regressions (7) and (12) at the 5 % level of significance.

Table 3.2
Restricted Regressions of Growth on Economic Variablies (1966-1992)

Dependent variable: annual log difference GDP per worker

	(7)	(8)	(9)	(10)	(11)	(12)
Constant	0.0967**	0.192**	0.208**	0.223**	0.228**	0.234**
	(0.0172)	(0.0503)	(0.0438)	(0.0355)	(0.0427)	(0.0365)
$\ln(y_{i,0})$	-0.0240**	-0.0305**	-0.0335**	-0.0345**	-0.0468**	-0.0460**
	(0.00494)	(0.00770)	(0.00669)	(0.00603)	(0.00982)	(0.0102)
$\ln(0.02+n_{i,t}+\delta_{i,t})$		-0.00299	-0.00269	-0.000347	-0.00680	-0.00528
		(0.00674)	(0.00679)	(0.00605)	(0.00688)	(0.00600)
$\ln(\Phi^{h}_{i,t})$		0.00784*	0.00555	0.00629*	0.0113**	0.0111**
		(0.00488)	(0.00486)	(0.00446)	(0.00539)	(0.00552)
$\ln(\Phi^{k}_{i,t})$		-0.00650	-0.00532	-0.00696	-0.00742	-0.00799
		(0.00794)	(0.00818)	(0.00722)	(0.00737)	(0.00674)
$\ln(\Phi^{g}_{i,t})$		0.00163				
		(0.00554)				
$\ln(\Phi^{g-tf}_{i,t})$			0.00744**	0.00671**	0.00567**	0.00549**
			(0.00294)	(0.00296)	(0.00296)	(0.00293)
$\ln(\Phi^{tf}_{i,t})$			-0.00498**	-0.00569*	-0.00277	-0.00333
			(0.00357)	(0.00350)	(0.00353)	(0.00358)
$\ln(gc_{i,t}/y_{i,t})$					-0.0123*	-0.0111*
					(0.00735)	(0.00782)
$\ln(x^{primary}_{i,t})$		0.0121**	0.0144**	0.0148**	0.0113**	0.0118**
		(0.00296)	(0.00250)	(0.00238)	(0.00295)	(0.00304)
$\ln(x^{manu}_{i,t})$		0.0134**	0.0165**	0.0173**	0.0124**	0.0131**
		(0.00363)	(0.00345)	(0.00341)	(0.00391)	(0.00439)
$\ln(x^{const}_{i,t})$		0.00460	0.00181	0.00374	0.00379	0.00512
		(0.0103)	(0.0102)	(0.00880)	(0.00933)	(0.00833)
$mr_{i,t}$				-0.000158		-0.0000751
				(0.000128)		(0.000134)
Adj. R^2	0.40	0.49	0.52	0.51	0.53	0.51
$\hat{\sigma}$	0.0051	0.0047	0.0046	0.0047	0.0045	0.0046
Wald test		0.017	0.59	0.98	0.013	0.73
Reset (4)	0.753	1.290	1.150	0.687	0.361	0.425

Note: Same as in Table 3.1.

Table 3.3
Implied Speed of Convergence and Elasticities from Restricted Regressions in Table 3.2

	(7)	(8)	(9)	(10)	(11)	(12)
Implied γ		0.138*	0.101	0.113*	0.217*	0.213*
		(0.0669)	(0.0777)	(0.0711)	(0.0716)	(0.0714)
Implied α		-0.114	-0.0972	-0.125	-0.143	-0.153
		(0.136)	(0.147)	(0.130)	(0.137)	(0.123)
Implied β		0.0286				
		(0.102)				
Implied β^{g-if}			0.136**	0.120**	0.189**	0.105*
			(0.0729)	(0.0669)	(0.0727)	(0.0721)
Implied β^{if}			-0.0910*	-0.102*	-0.0532	-0.0637
			(0.0593)	(0.0611)	(0.0694)	(0.0732)
Implied λ	0.0266**	0.0349**	0.0399**	0.0404**	0.0586**	0.0574**
	(0.00611)	(0.0107)	(0.00914)	(0.00833)	(0.0157)	(0.0161)

Table 3.4
Comparison of Cross-country and Cross-state Elasticities and the Speed of convergence

	Implied γ	Implied $\alpha+\beta$	Implied λ
U.S. states(1)			0.0222
			(0.0065)
U.S. states(2)	0.333	0.288	0.0450
	(0.0216)	(0.0267)	
OECD(3)	0.23	0.38	0.0206
	(0.11)	(0.13)	(0.0020)
Intermediate 78 countries(3)	0.23	0.44	0.0186
	(0.05)	(0.07)	(0.0019)
Non-oil 98 countries(3)	0.23	0.48	0.0142
	(0.05)	(0.07)	(0.0019)

Notes: (1) Barro and Sala-i-Martin, 1992a, p. 237. The sectoral composition variable is included in the estimation. The estimated results are over the 1963-86 period.
(2) Holtz-Eakin, 1993, p. 435. Controlled for initial income, variations in resource endowments, and urban area. The estimated results are for the 1973-86 period. The speed of convergence is calculated using the estimated parameters and data for 1986, p. 437.
(3) Mankiw, Romer and Weil, 1992, p. 429. The estimated results are for the 1960-85 period. Differences in the industry mix are not considered.

The estimated speed of unconditional convergence is 2.7 per cent per year for Canada. This is fairly close to 2.2 per cent per year obtained by Barro and Sala-i-Martin (1992) for the U.S. states as shown in Table 3.4.[22] Once we include human and physical investment, and different industry mix, the estimates of speed of convergence are between 4.0 and 5.7 per cent per year. The estimates are fairly close to the one for the U.S. states (4.5 per cent) but lower than those other countries (between 1.4 and 2.1 per cent). There are at least two reasons why the estimates of Canada's conditional speed of convergence are higher than those for cross-country convergence. First, our estimates account for differences in the industry mix while the estimates of cross-country convergence do not take account of these differences. Second, the estimated elasticity of output with respect to physical capital is 0.19,[23] suggesting that diminishing returns to physical capital set in much quicker in Canada than in the United States or other countries due to high inter-provincial capital flows. This, in turn, causes a higher convergence speed. In any case, from these comparisons, we conclude that the speed of conditional convergence increases as the economies become similar, that is, the speed of convergence is faster with-in country than cross-country.

4. Conclusion

Our main empirical results are:

C1. The relationship between the growth rate of output per worker and the initial level of output per worker is significantly negative.

C2. Regional differences in productivity growth are significantly related to differences in the industry mix.

C3. A proxy for human capital is positively associated with productivity growth. This relationship becomes much more significant when differences in inter-provincial migration are allowed for.

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[22] There are some differences between the two estimates. We focus on GPP per worker whereas Barro and Sala-i-Martin (1992a) focused on GSP per capita.

[23] This is taking the highest number in Table 3.3, from regression (11). The elasticity of output with respect to private capital is not significantly different from zero.

C4. Both private and public investment rates are not significantly related to productivity growth. This suggests that capital mobility in Canada reduces disparities caused by differences in savings across provinces.

C5. Public investment excluding government investment in non-residential construction is positively correlated with productivity growth.

C6. Government consumption is negatively related with productivity growth while taxes are not.

Appendix A: Linearization around the Steady State

The linear approximation of the natural logarithm of output per effective worker around the steady state given by the following expression using a Taylor series approximation:

$$\frac{d(\ln \hat{y}_t)}{dt} \approx \frac{d(\ln \hat{y}_t)}{dt}\bigg|_{\ln \hat{y}^*} + \frac{d(\ln \hat{y}_t)/dt}{d\ln \hat{y}_t}\bigg|_{\ln \hat{y}^*} \bullet (\ln \hat{y}_t - \ln \hat{y}^*). \tag{A1}$$

The first term on the right-hand side in equation (A1) drops out since the growth rate of output per effective worker is zero in the steady state. Thus, we only need to focus on the second term.

Using equations (4), (5), (6) and (7), we obtain the following expression:

$$\frac{d(\ln \hat{y}_t)}{dt} = -(\gamma + \alpha + \beta)(g + n + \delta) + \gamma s_h\left(\frac{\hat{y}_t}{\hat{h}_t}\right) + \alpha s_k\left(\frac{\hat{y}_t}{\hat{k}_t}\right) + \beta s_g\left(\frac{\hat{y}_t}{\hat{g}_t}\right). \tag{A2}$$

Taking derivatives of equation (A2) with respect to $\ln y_t$ and simplifying yields,

$$\frac{d(d\ln \hat{y}_t/dt)}{d\ln \hat{y}_t} = \gamma s_h\left(\frac{\hat{y}_t}{\hat{h}_t}\right) + (\alpha - 1)s_k\left(\frac{\hat{y}_t}{\hat{k}_t}\right) + \beta s_g\left(\frac{\hat{y}_t}{\hat{g}_t}\right)$$

$$-\left[\beta s_g\left(\frac{\hat{y}_t}{\hat{g}_t}\right) - \beta s_k\left(\frac{\hat{y}_t}{\hat{k}_t}\right)\right]\left[\frac{d\ln \hat{g}_t}{d\ln \hat{y}_t}\right] - \left[\gamma s_h\left(\frac{\hat{y}_t}{\hat{h}_t}\right) - \gamma s_k\left(\frac{\hat{y}_t}{\hat{k}_t}\right)\right]\left[\frac{d\ln \hat{h}_t}{d\ln \hat{y}_t}\right]. \tag{A3}$$

Evaluating the derivative at the steady state using steady state relations based on equations (8), (9), (10) and (11) yields:

$$\frac{d(d(\ln \hat{y}_t)/dt)}{d\ln \hat{y}_t}\bigg|_{\ln \hat{y}^*} = -(1 - \gamma - \alpha - \beta)(g + n + \delta). \tag{A4}$$

Substituting equation (A4) into equation (A1), we have an expression for the speed of convergence:

$$\frac{d(\ln \hat{y}_t)}{dt} = \lambda(\ln \hat{y}^* - \ln \hat{y}_t). \qquad \text{(A5)}$$

where $\lambda = (1-\gamma-\alpha-\beta)(g+n+\delta)$.

Appendix B: Data Definitions and Sources

List of Variables and Parameters

Variable	Definition	Source
$GPPM_{i,t}$	Gross provincial product at market price	1966-1992 CANSIM (D31544, D31558, D31572, D31586, D31600, D31614, D31628, D31642, D31656, D44000, D31530)
$IT_{i,t}$	Indirect taxes net of subsidies	1966-1992 CANSIM (D12547, D12549, D12551, D12553, D12555, D12557, D12559, D12561, D12563, D12565, D20008)
$YN_{i,t}$	Gross provincial product at factor cost $= (GPPM_{i,t} - IT_{i,t})$	1966-1992
$P_{i,t}$	GPP Deflators for provinces GDP Deflators for Canada	1966-1992: Conference Board 1966-1992: CANSIM (D20556)
$Y_{i,t}$	GPP at factor cost in 1986$ $= (YN_{i,t}/P_{i,t})$	1966-1992
$N_{i,t}$	Employment 15 years and over	1966-1992 CANSIM (D768890, D769857, D768616, D769890, D769839, D769902, D769946, D769967, D769988, D769920, D767888)
$y_{i,t}$	GPP at factor cost per worker $= (Y_{i,t}/N_{i,t})$	1966-1992
$n_{i,t}$	Employment growth $= (N_{i,t} - N_{i,t-1})/N_{i,t-1}$	1966-1992
$POP15_{i,t}$	Population 15 years and over	1966-1992 CANSIM (D768787, D769855, D768606, D769889, D769837, D769900, D769944, D769965, D769986, D769918, D767867)

$UD_{i,t}$	Proportion of working-age population with University degree	1961, 1971, 1975-1991 Statistics Canada Catalogue 93-110, 93-328, and 71-529
$H_{i,t}$	$= UD_{i,t}$ $= UD_{i,t_0} + (T-t)\frac{UD_{i,T} - UD_{i,t_0}}{T-t_0}$	1961, 1971, 1975-1991 1962-1970, 1972-1974
$\Phi^h_{i,t}$	Proportion of workers University Degree $= H_{i,t} * (POP15_{i,t}/N_{i,t})$	1966-1992 ?
$IN^{res}_{i,t}$	Gross business investment in residential construction in current prices	1966-1970 CANSIM (D31733, D31755, D31773, D31799, D31821, D31843, D31865, D31887, D31909, D44025, D31711)
$IN^{nres}_{i,t}$	Gross business investment in non-residential construction in current prices	1966-1970 Statistics Canada, Unpublished Data
$I^{nres}_{i,t}$	Gross business investment in non-residential construction in 1986 prices	1966-1970 Ststistics Canada, Unpublished Data
$I^{res}_{i,t}$	Gross business investment in residential construction at 1986 prices $= IN^{res}_{i,t} / (IN^{nres}_{i,t} / I^{nres}_{i,t})$	1966-1970 1971-1992 CANSIM (D44511, D44529, D44547, D44565, D44583, D44601, D44619, D44637, D44655, D44673, D44493)
$I^{k-res}_{i,t}$	Gross business investment excluding residential construction at 1986 prices	1966-1992 Statistics Canada, Unpublished Data
$I^{k}_{i,t}$	Gross business investment at 1986 prices $= I^{k-res}_{i,t} + I^{res}_{i,t}$	1966-1992

$I^{g}_{i,t}$	Gross non-business investment at 1986 prices	1966-1992 Statistics Canada, Unpublished Data
$I^{g-tf}_{i,t}$	Gross non-business investment excluding government non-residential construction at 1986 prices	1966-1992 Statistics Canada, Unpublished Data
$I^{tf}_{i,t}$	Gross government investment in in non-residential construction at 1986 prices	1966-1992 Statistics Canada, Unpublished Data
$\Phi^{k}_{i,t}$	Ratio of business investment to output at 1986 prices = $I^{k}_{i,t}$ /Yi,t	1966-1992
$\Phi^{g}_{i,t}$	Ratio of non-business investment to output at 1986 prices = $I^{g}_{i,t}$ /Yi,t	1966-1992
$\Phi^{g-tf}_{i,t}$	Ratio of non-business investment excluding government investment in non-residential construction to output = $I^{g-tf}_{i,t}$ /Yi,t	1966-1992
$\Phi^{tf}_{i,t}$	Ratio of government investment in non-residential construction to output = $I^{tf}_{i,t}$/Yi,t	1966-1992
$K^{k-res}_{i,t}$	Capital stock for the business sector excluding residential construction at 1986 prices	1966-1992 Statistics Canada, Unpublished Data
$K^{g}_{i,t}$	Capital stock for the non-business sector at 1986 prices	1966-1992 Statistics Canada, Unpublished Data
$\delta_{i,t}$	Depreciation rate $= \left[\frac{K^{k-res}_{i,t}}{K^{k-res}_{i,t}+K^{g}_{i,t}}\right]\left[\frac{I^{k-res}_{i,t}-(K^{k-res}_{i,t}-K^{k-res}_{i,t-1})}{K^{k-res}_{i,t-1}}\right]$ $+\left[\frac{K^{g}_{i,t}}{K^{k-res}_{i,t}+K^{g}_{i,t}}\right]\left[\frac{I^{g}_{i,t}-(K^{g}_{i,t}-K^{g}_{i,t-1})}{K^{g}_{i,t-1}}\right]$	1966-1992

$CPI_{i,t}$	Consumer price index Provinces Canada	1966-1992 Conference Board CANSIM (D484000)
$GC_{i,t}$	Government current expenditure on goods and services in current prices	1966-1992 CANSIM (D31724, D31746 D31768, D31790, D31812, D31834, D31856, D31878, D31900, D44018, D31702)
$gc_{i,t}/y_{i,t}$	Ratio of government consumption to output $= (GC_{i,t}/CPI_{i,t})/Y_{i,t}$	1966-1992
$VA^{j}_{i,t}$	Value added for jth industry in current prices	1966-1970 Statistics Canada Catalogue 61-202
$YN^{forestry}_{i,t}$	GDP at factor cost for forestry in current prices	1971-1980 Statistics Canada Catalogue 15-203
$YN^{min\ ing}_{i,t}$	GDP at factor cost for mining in current prices	1971-1983 Statistics Canada Catalogue 15-203
$Y^{j}_{i,t}$	GDP at factor cost for jth industry at 1986 prices	1971-1991 Statistics Canada Catalogue 61-202 Statistics Canada Catalogue 15-203
$x^{agric}_{i,t}$	Ratio of agricultureral output to GPP	
	$= VA^{agric}_{i,t}$ /YNi,t	1966-1970
	$= Y^{agric}_{i,t}$ /Yi,t	1971-1991
$x^{forestry}_{i,t}$	Ratio of forestry output to GPP	
	$= VA^{forestry}_{i,t}$ /YNi,t	1966-1970
	$= YN^{forestry}_{i,t}$ /YNi,t	1971-1980
	$= Y^{forestry}_{i,t}$ /Yi,t	1980-1991
$x^{min\ ing}_{i,t}$	Ratio of mining output to GPP	
	$= VA^{min\ ing}_{i,t}$/YNi,t	1966-1970
	$= YN^{min\ ing}_{i,t}$/YNi,t	1971-1983
	$= Y^{min\ ing}_{i,t}$/Yi,t	1984-1991
$x^{pri}_{i,t}$	Ratio of primary output to GPP	
	$= x^{agric}_{i,t} + x^{forestry}_{i,t} + x^{min\ ing}_{i,t}$	1966-1991

$x_{i,t}^{cons}$	Ratio of construction output to GPP $= YN_{i,t}^{cons} / Y_{i,t}$ $= Y_{i,t}^{cons} / Y_{i,t}$	 1966-1970 1971-1991
$PDT_{i,t}$	Personal Direct Tax	1966-1992 CANSIM (D12601, D12619, D12637, D12655, D12673, D12691, D12709, D12727, D12745, D12763, D11132)
$CDT_{i,t}$	Corporate Direct Tax	1966-1992 CANSIM (D12602, D12620, D12638, D12656, D12674, D12692, D12710, D12728, D12746, D12764, D11133)
$NR_{i,t}$	Non-residential Tax	1966-1992 CANSIM (D12603, D12621, D12639, D12657, D12675, D12693, D12711, D12729, D12747, D12765, D11134)
$IT_{i,t}$	Indirect Tax	1966-1992 CANSIM (D12604, D12622, D12640, D12658, D12676, D12694, D12712, D12730, D12748, D12766, D11135)
$tax_{i,t}/y_{i,t}$	Ratio of tax to output at 1986 prices $= [(PDT_{i,t}+CDT_{i,t}+NR_{i,t}+IT_{i,t})/CPI_{i,t}]/Y_{i,t}$	1966-1992
$mr_{i,t}$	Net migration per 1000 of population	1966-1992 CANSIM (D122704-D122713)

Appendix C: Estimated Results for Equation (19)

Table C.1
Regessions of Productivity Level on Economic Variables (1968-1992)

Dependent variable: log GDP per worker

	(C1)	(C2)	(C3)	(C4)	(C5)	(C6)
Constant	4.097*	4.693**	4.588**	6.501**	4.045**	5.603**
	(0.484)	(0.482)	(0.480)	(0.831)	(0.424)	(0.833)
$\ln(0.02+n_{i,t}+\delta_{i,t})$	0.204	0.0813	0.0969	0.443**	-0.0710	0.219*
	(0.121)	(0.0981)	(0.101)	(0.148)	(0.113)	(0.163)
$\ln(\Phi^{h}_{i,t})$	0.134	0.0799	0.0824	0.345**	0.336**	0.510**
	(0.109)	(0.103)	(0.101)	(0.123)	(0.110)	(0.0997)
$\ln(\Phi^{k}_{i,t})$	0.370**	0.0653	0.0654	0.118*	-0.00828	0.0415
	(0.112)	(0.0907)	(0.0909)	(0.0802)	(0.0606)	(0.0615)
$\ln(\Phi^{g}_{i,t})$	-0.256	-0.210**				
	(0.0598)	(0.0524)				
$\ln(\Phi^{g-if}_{i,t})$			-0.103**	-0.129**	-0.0472*	-0.0738**
			(0.0491)	(0.0451)	(0.0315)	(0.0288)
$\ln(\Phi^{if}_{i,t})$			-0.104**	-0.0193	-0.0325	0.0 251
			(0.0518)	(0.0605)	(0.0426)	(0.0465)
$\ln(gc_{i,t}/y_{i,t})$					-0.317**	-0.279**
					(0.0750)	(0.0597)
time	0.0304	0.118**	0.124**	0.0604*	0.0132	-0.0232
	(0.0315)	(0.0352)	(0.0375)	(0.0388)	(0.0489)	(0.0363)
$\ln(x^{primary}_{i,t})$		0.288**	0.284**	0.211**	0.0921**	0.0583*
		(0.0372)	(0.0402)	(0.0427)	(0.00523)	(0.0434)
$\ln(x^{manu}_{i,t})$		0.343**	0.340**	0.292**	0.0807	0.0745
		(0.0645)	(0.0655)	(0.0549)	(0.0814)	(0.0627)
$\ln(x^{const}_{i,t})$		0.0527	0.0599	0.0174	0.145	0.224**
		(0.114)	(0.113)	(0.108)	(0.0827)	(0.0753)
$mr_{i,t}$				-0.0114**		-0.00893**
				(0.00392)		(0.00379)
Adj. R^2	0.68	0.84	0.84	0.86	0.88	0.89
$\hat{\sigma}$	0.085	0.059	0.061	0.057	0.053	0.050
Reset (4)	1.197	0.903	1.031	1.019	2.358	1.595

Note: Same as in Table 3.1.

Table C.2
Restricted Regessions of Productivity Level on Economic Variables (1968-1992)

Dependent variable: log GDP per worker

	(C7)	(C8)	(C9)	(C10)	(C11)	(C12)
Constant	2.898**	4.741**	4.530**	5.482**	3.857**	3.814**
	(0.157)	(0.471)	(0.361)	(0.580)	(0.339)	(0.357)
$\ln(0.02+n_{i,t}+\delta_{i,t})$	0.0841	0.0705	0.0866	0.304**	-0.0968	-0.106
	(0.786)	(0.0970)	(0.0832)	(0.127)	(0.104)	(0.119)
$\ln(\Phi^{h}_{i,t})$	-0.0727	0.108	0.0723	0.162**	0.265**	0.267**
	(0.0932)	(0.0894)	(0.0903)	(0.0822)	(0.103)	(0.108)
$\ln(\Phi^{k}_{i,t})$	0.342**	0.0881	0.0558	0.0438	-0.0413	-0.0390
	(0.115)	(0.0753)	(0.0885)	(0.0730)	(0.0642)	(0.0632)
$\ln(\Phi^{g}_{i,t})$	-0.354**	-0.196**				
	(0.0600)	(0.0551)				
$\ln(\Phi^{g-ff}_{i,t})$			-0.103**	-0.129**	-0.0548*	-0.0526*
			(0.0506)	(0.0535)	(0.0387)	(0.0379)
$\ln(\Phi^{ff}_{i,t})$			-0.111**	-0.0768*	-0.0717*	-0.0689*
			(0.0506)	(0.0560)	(0.0458)	(0.0445)
$\ln(gc_{i,t}/y_{i,t})$					-0.281**	-0.288**
					(0.0827)	(0.0918)
time	0.0749**	0.109**	0.126**	0.109**	0.0348	0.0335
	(0.0302)	(0.0312)	(0.0366)	(0.0326)	(0.0495)	(0.0521)
$\ln(x^{primary}_{i,t})$		0.284**	0.288**	0.254**	0.131**	0.128**
		(0.0350)	(0.0381)	(0.0394)	(0.0557)	(0.0591)
$\ln(x^{manu}_{i,t})$		0.336**	0.344**	0.330**	0.126*	0.121
		(0.0619)	(0.0637)	(0.0562)	(0.0857)	(0.0944)
$\ln(x^{const}_{i,t})$		0.0314	0.0677	0.165*	0.169**	0.162**
		(0.119)	(0.122)	(0.124)	(0.0970)	(0.0868)
$mr_{i,t}$				-0.00605**		0.000390
				(0.00280)		(0.00186)
Adj. R^2	0.64	0.85	0.84	0.85	0.88	0.87
$\hat{\sigma}$	0.090	0.058	0.059	0.057	0.053	0.054
Wald test	6.47	0.014	0.074	3.55	2.31	7.22
Reset (4)	3.768	1.013	1.005	1.085	2.222	2.433

Note: Same as in Table 3.1.

Table C.3 Implied Elasticities from Restricted Regressions in Table C.2

	(C7)	(C8)	(C9)	(C10)	(C11)	(C12)
Implied γ	-0.0794	0.107	0.0705	0.150**	0.226**	0.227**
	(0.109)	(0.0893)	(0.0865)	(0.0764)	(0.0737)	(0.0739)
Implied α	0.373**	0.0881	0.0544	0.0406	-0.0353	-0.0332
	(0.107)	(0.0753)	(0.0837)	(0.0678)	(0.0559)	(0.0548)
Implied β	-0.386**	-0.196**				
	(0.0921)	(0.0551)				
Implied β^{g-ff}			-0.100**	-0.120**	-0.0469*	-0.0448
			(0.0508)	(0.0497)	(0.0347)	(0.0342)
Implied β^{ff}			-0.108**	-0.0713*	-0.0613*	-0.0586*
			(0.0502)	(0.0520)	(0.0385)	(0.0376)

Appendix D: Ratios of Investments and Government Consumption

FIGURE D.1 Ratio of Private Investment to GPP

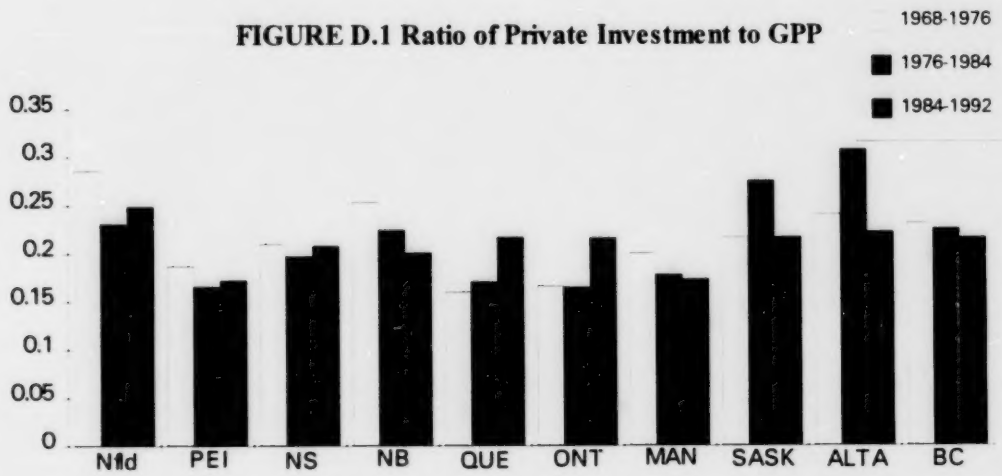


FIGURE D.2 Ratio of Public Investment Excluding Government Investment in Non-residential Construction to GPP

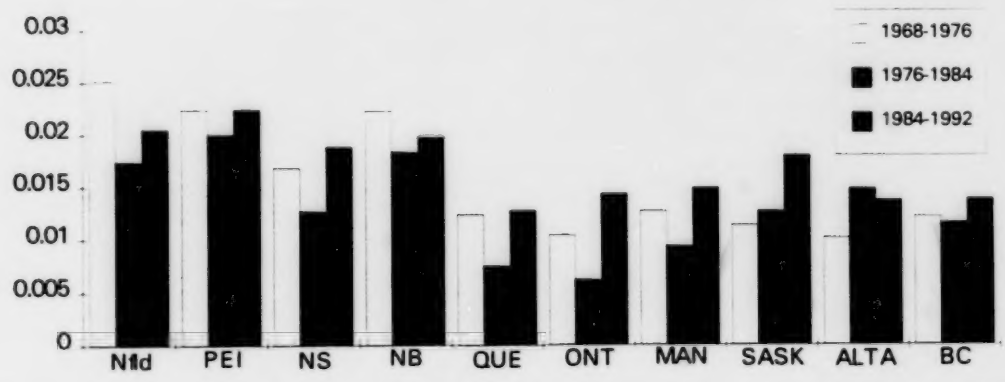


FIGURE D.3 Ratio of Government Investment in Non-residential Construction to GPP

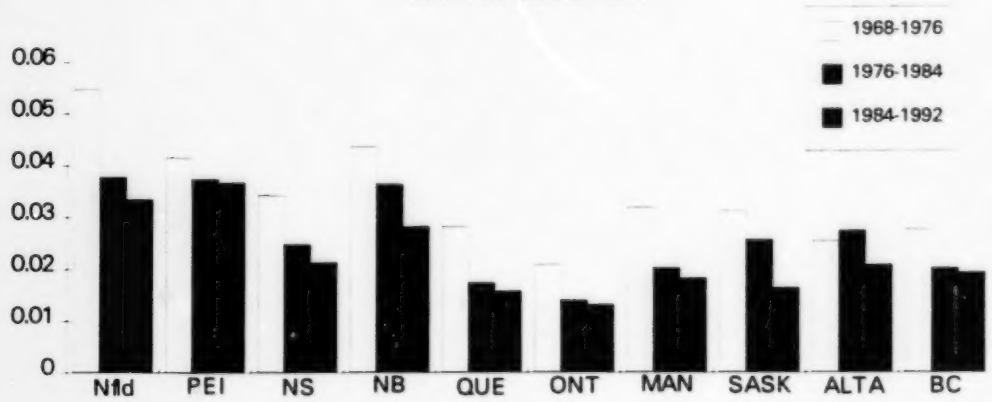
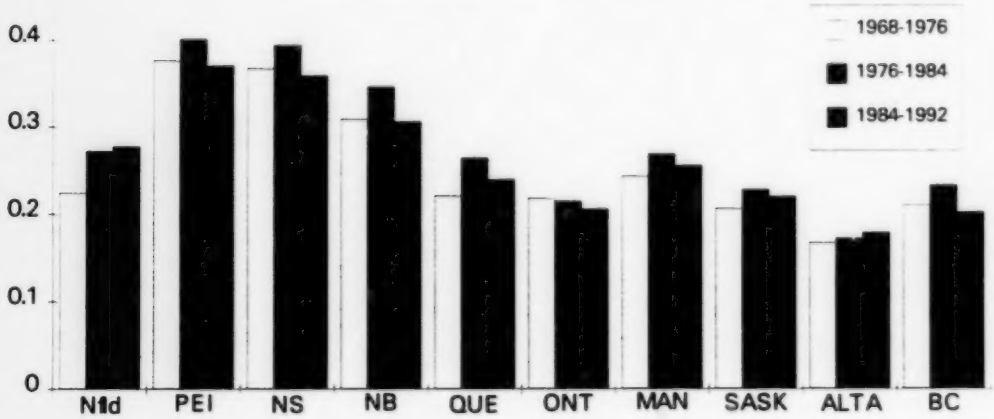


FIGURE D.4 Ratio of Government Consumption to GPP



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